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LOADMAN

COMPARISON OF TEST RESULTS OBTAINED USING LOADMAN WITH THOSE OBTAINED USING
- A FALLING WEIGHT DEFLECTOMETER AND
- A PLATE BEARING INSTRUMENT

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ROAD ADMINISTRATION

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and Studies

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Development

ABSTRACT

The aim of this study is to determine whether the LOADMAN unit is suitable for use as a measuring instrument for quality assurance purposes in road construction. A falling weight deflectometer and a plate bearing unit were used as reference instruments to verify the results.

A Loadman unit requires great care on the part of the operator. The results seem to indicate that a total of four consecutive measurements should be made at one measuring point. The two first measurements should then be ignored and the average of the two next ones selected as the final result. This will give a standardized result which can be repeated in subsequent measurements.

All three measuring units give similar results, although there is some deviation in the level of magnitude, which can probably be corrected.

The applicability of the study should be improved with regard to Loadman by conducting a further survey based on long-term measurements at an actual road construction site. This would help determine the effects of the various materials and the reliability of the unit in operation.

CONTENTS

1. PURPOSE AND OBJECTIVE OF THE STUDY

The purpose of the study was to determine the functionality and suitability of the lightweight LOADMAN falling weight deflectometer for measuring the load-bearing capacity and compaction of the unbound layers of a road structure. The unit is intended for use as a quality control device in the construction of the layers.

The results of the study can be used by the FINNISH NATIONAL ROAD ADMINISTRATION mainly as an aid when planning equipment purchases and comparing the measurements obtained with different methods and their mutual correspondence.

2. DATE AND SITE

The field measurements were carried out on 24 - 25 October 1990 at the Kivimaki Crushing Plant at Lavia in Turku Road Maintenance District.

3. EQUIPMENT TESTED

- Falling weight deflectometer KUAB FWD 50
- Plate bearing unit complete with an automatic data recording unit.
- Lightweight Loadman falling weight deflectometer (brochure enclosed)
    - Unit weight 18 kg
    - Height 117 cm
    - Base plate diameter 11 cm / 20 cm
    - Operating voltage (3 x 9V) = 27 V
    - Drop = impact about 1,200 kPa using a 11 cm base plate.

4. TEST METHODS

For the measurements, four test beds with a length of 30 m were constructed at the bottom of the stockpiling area. Chrushed rock aggregate with a particle size of 0 to 45 mm was used for construction the following test layers:

- 20 cm thick bed simulating a base course layer
- 30 cm thick bed simulating a base course layer
- 40 cm thick bed simulating a base course layer.

Chrushed rock aggregate with a particle size of 0 to 16 mm was used for constructing a 20 cm thick test layer.

Measurements were carried out on the test beds as follows:

- Loadman: ten measurements at ten measuring points per cycle = 400 measurements.

- KUAB falling weight deflectometer: one measurement at ten measuring points per cycle = 40 measure ments.

- Plate bearing measurements at ten measuring points per cycle = 40 measurements.

Additional measurements were performed on an old oiled-gravel road.

5.TEST RESULTS

The readings obtained with the test instruments were converted to the same unit to enable the graphics software to plot the comparison curves.

The curves so obtained are relative and cannot be directly compared with other results if the units used in previous tests are different.

5.1 Loadman

An analysis of the performance of the Loadman measuring instrument gives rise to the following observations:

Method of measurement: the base must be level with no individual coarse particles. The base must be levelled with a thin layer of sand just as in plate bearing measurements. To perform the drop, it must be ensured that the unit is "free-standing" in as vertical a position as possible (see the video tape).

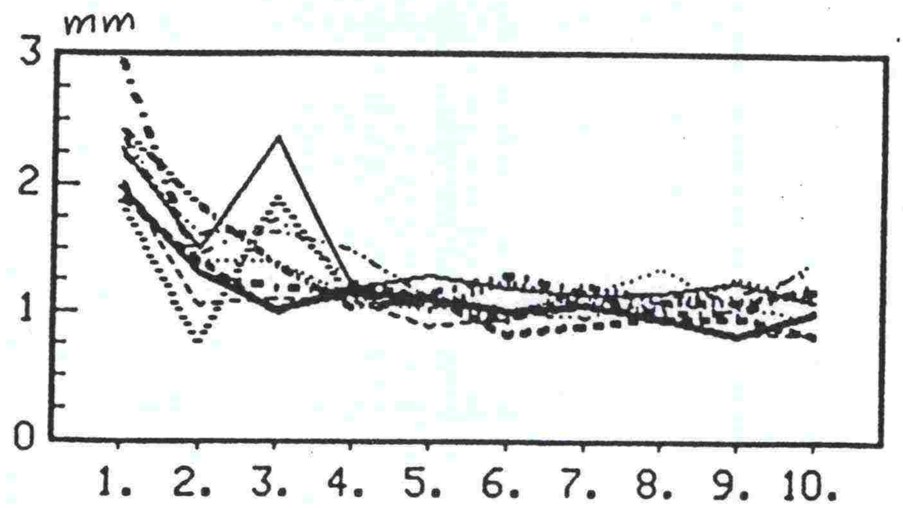
Of the 440 measurements carried out, 16, or 3.6%, were "erratic" or illogical, the source of which could not be identified.

When examining the variation of the results obtained for each individual measuring point (10 consecutive measurements), we see that the variation for the different layer thicknesses of the same material was similar.

With finer material, the variation increased as the following curves indicate:

Fig. 1. COMPARISON OF INSTRUMENTS MEASURING LOAD-BEARING CAPACITY/COMPACTION 1990

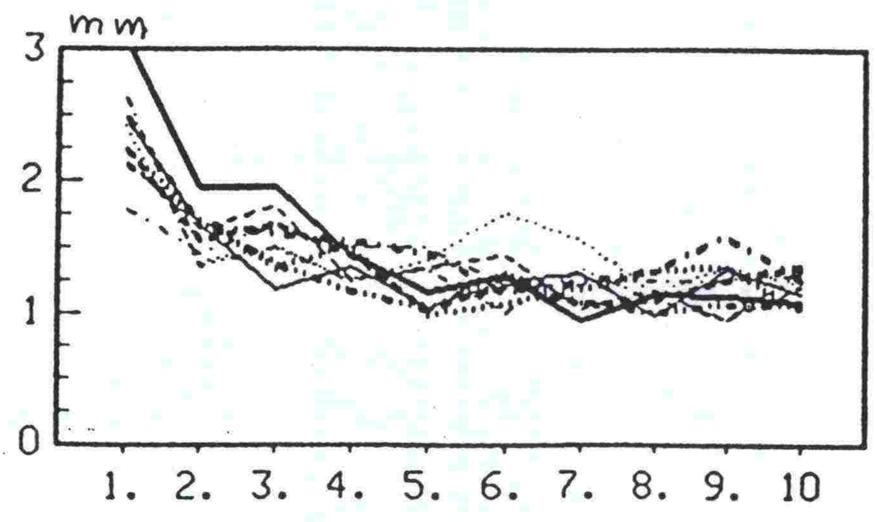
Results of 10 consecutive measurements performed at one measuring point (0-45/20)



(Number of measurements)

Fig. 2. COMPARISON OF INSTRUMENTS MEASURING LOAD-BEARING CAPACITY/COMPACTION 1990

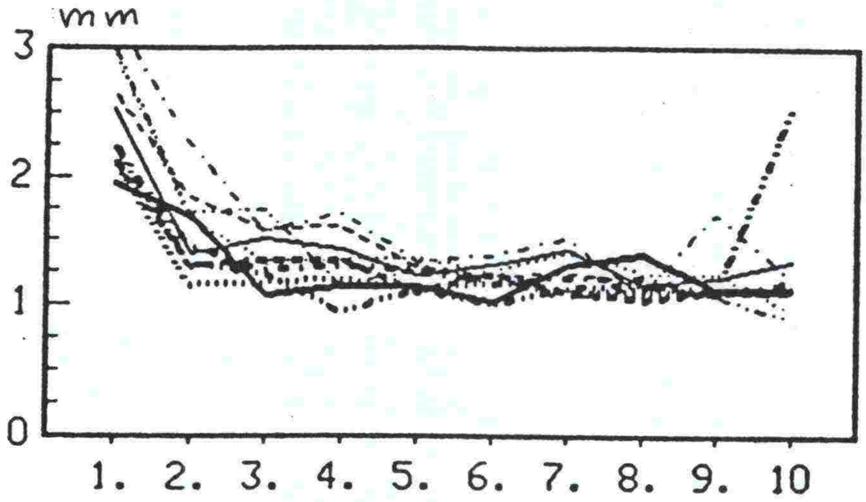
Results of 10 consecutive measurements performed at one measuring point (0-45/30)



(Number of measurements)

Fig. 3. COMPARISON OF INSTRUMENTS MEASURING LOAD-BEARING CAPACITY/COMPACTION 1990

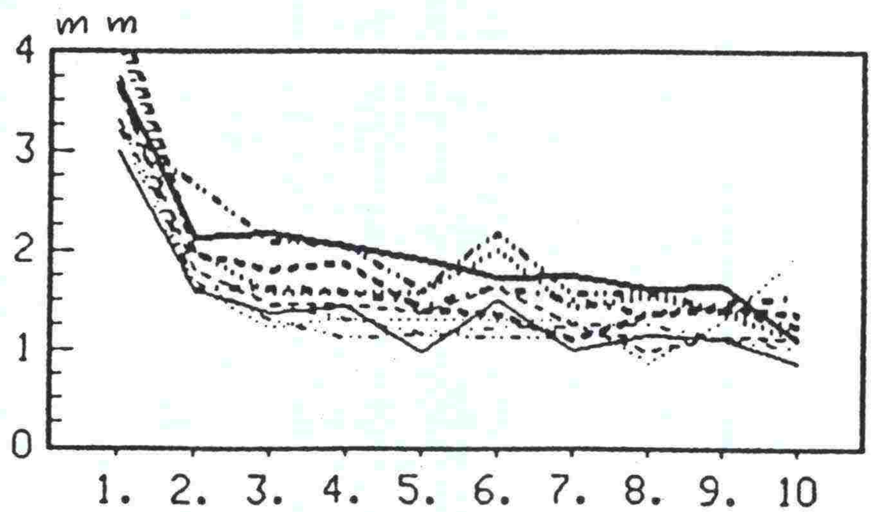
Results of 10 consecutive measurements performed at one measuring point (0-45/40)



(Number of measurements)

Fig. 4. COMPARISON OF INSTRUMENTS MEASURING LOAD-BEARING CAPACITY/COMPACTION 1990

Results of 10 consecutive measurements performed at one measuring point (0-16/20)



(Number of measurements)

From the curves we may conclude that the readings obtained in the first and second of all the consecutive measurements made at one measuring point were greater than the readings obtained in subsequent measurements.

To achieve sufficient reliability, it is advisable to perform several measurements at one measuring point.

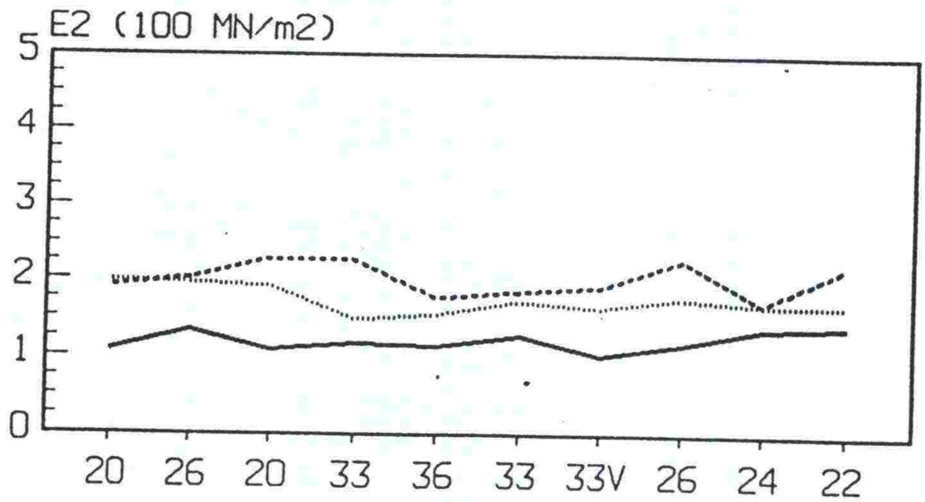
5.2 Comparison of results obtained with different measuring instruments

Readings obtained with the different measuring instruments at one measuring point. The thickness of the layer was also measured at the measuring points.

Fig. 5. COMPARISON OF INSTRUMENTS MEASURING LOAD-BEARING CAPACITY/COMPACTION 1990

Comparison measurements at one measuring point using different instruments (0-45/20) (1)

..........Plate bearing unit
------Falling weight deflectometer
———— Loadman



(Number of measurements)
(Layer thickness (cm) on test sites)

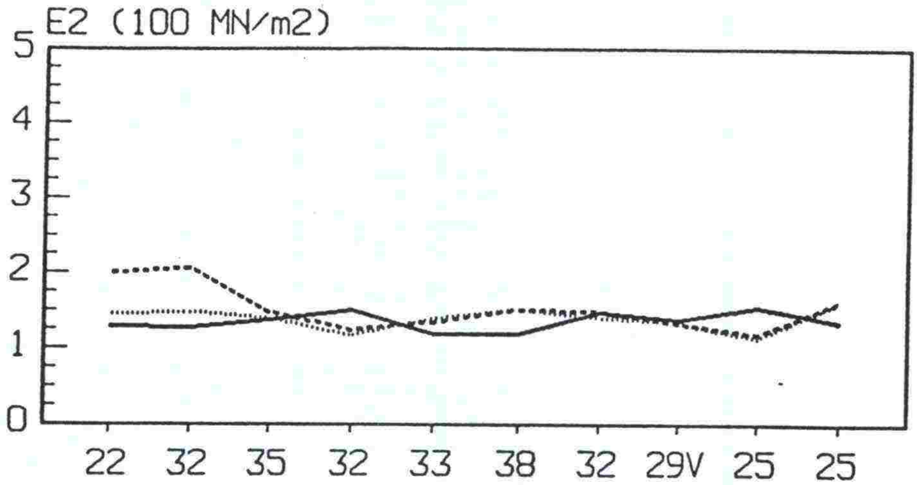
As the curves show, the results obtained with the different measuring instruments for the 20 cm thick layer do not fully correlate with one another. However, the readings are comparable providing that the initial difference is taken into account.

Variations in the thickness of the aggregate layer did not have any direct effect on the results of the measurements.

Fig. 6. COMPARISON OF INSTRUMENTS MEASURING LOAD-BEARING CAPACITY/COMPACTION 1990

Comparison measurements at one measuring point using different
instruments (0-45/340) (2)

·········· Plate bearing unit
- - - - - Falling weight deflectometer
——— Loadman



(Number of measurements)
(Layer thickness (cm) on test sites)

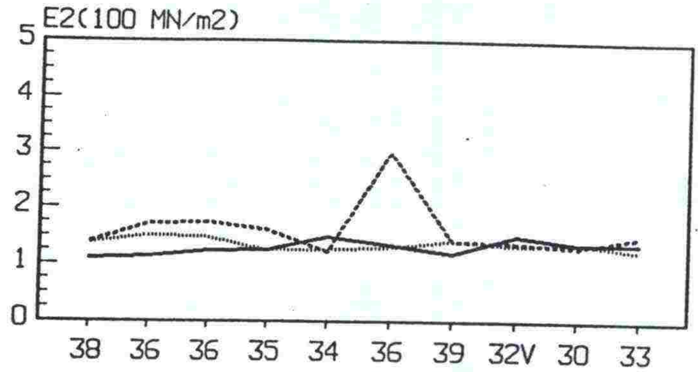
Readings obtained with the different measuring instruments for the 30 cm thick layer were considerably closer to one another than those obtained for the 20 cm thick layer. Variation in the thickness of the layer did not have any significant effect on the results obtained.

The slight variation observed may be caused by a separation of the fractions present in the layer, the effect of which is more pronounced in the thinner material layer.

Fig. 7. COMPARISON OF INSTRUMENTS MEASURING LOAD-BEARING CAPACITY/COMPACTION 1990

Comparison measurements at one measuring point using different
instruments (0-45/40) (3)

.... Plate bearing unit
------ Falling weight deflectometer
——— Loadman

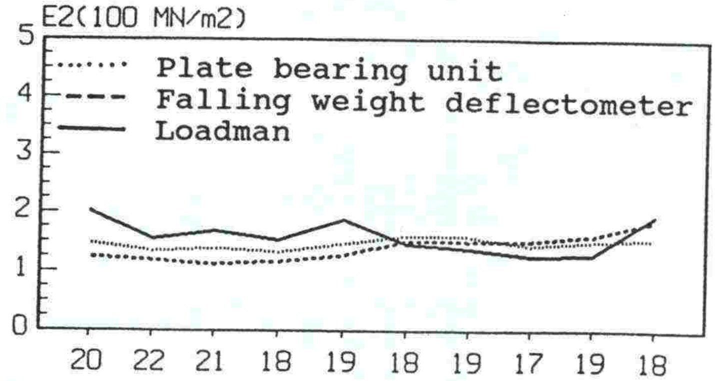


(Number of measurements)
(Layer thickness (cm) on test sites)

The results obtained for the 40 cm thick layer were similar, except for one deviant reading obtained with the falling weight deflectometer. No cause for the deviation could be found. Slight variations in the results may also be explained by a separation of the fractions present in the layer.

Fig. 8. COMPARISON OF INSTRUMENTS MEASURING LOAD-BEARING CAPACITY/COMPACTION 1990

Comparison measurements at one measuring point using different
instruments (0-16/20) (1)



(Number of measurements)
(Layer thickness (cm) on test sites)

The curve representing the results obtained with the Loadman instrument for coarse aggregate remains lower than those representing the results obtained with the other measuring instruments at one measuring point. Conversely, Loadman's curve for fine materials remains higher than those of other instruments in the early stages of the test cycle.

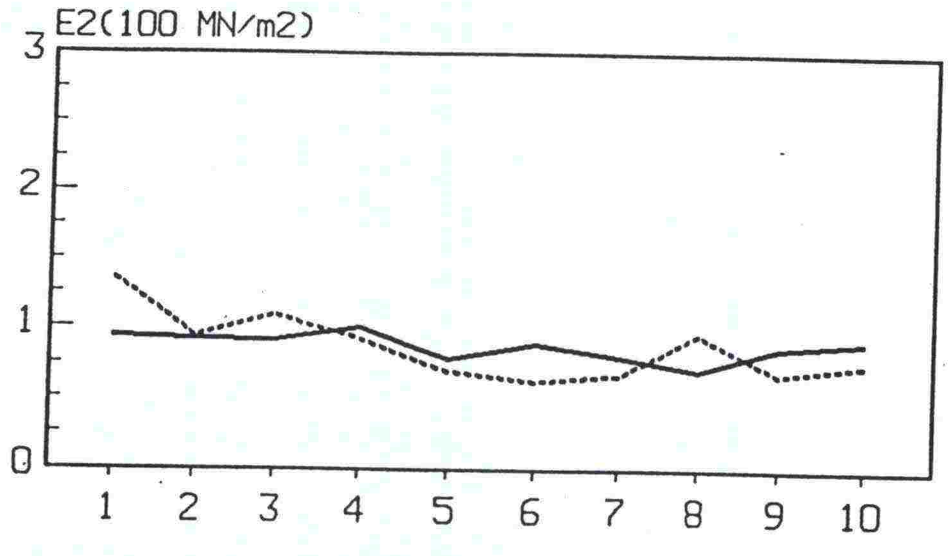
An experiment was also carried out by making measurements using the Loadman unit with a base plate with a diameter of 20 cm. The thickness of the test bed consisting of chrushed rock aggregate with a particle size of 0 to 16 mm was 20 cm.

Two complete series of measurements were performed without making any control measurements.

Fig. 9. COMPARISON OF INSTRUMENTS MEASURING LOAD-BEARING CAPACITY/COMPACTION 1990

Results of 10 consecutive measurements performed at one measuring point (0-16/20/20) (1)

——— first serie
- - - - second serie



(Number of measurements)

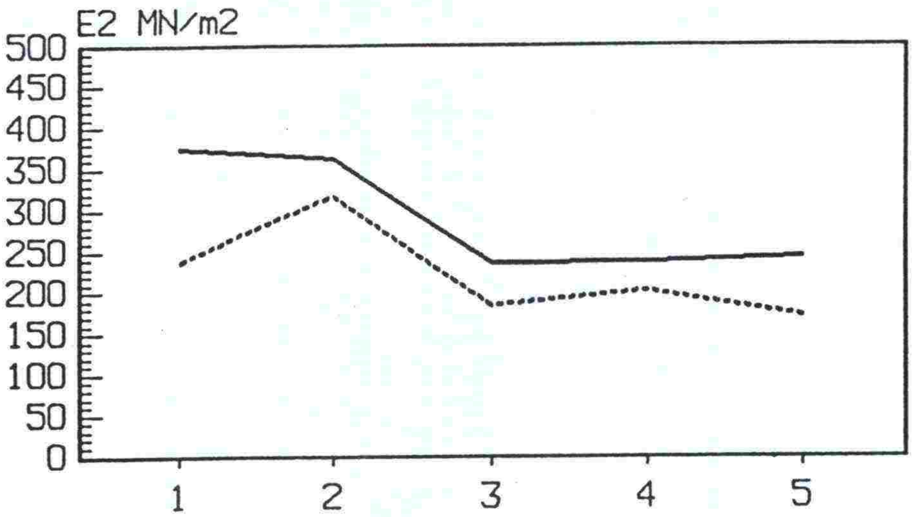
According to the curves, the results obtained in the various measurements differ somewhat. This may be partly due to a measurement error and partly to the error caused by a separation of the fractions in the embankment material. Also, the moisture content of the material may affect the results because materials with a different moisture content compact differently.

The results obtained with Loadman and the falling weight deflectometer were also compared with regard to measurements performed on a bound layer. The site consisted of an old oiled-gravel road section. The substrate should be levelled with sand to ensure adequate repeatability. A change in the vertical orientation of the unit affected the readings.

Fig. 10. COMPARISON OF INSTRUMENTS MEASURING LOAD-BEARING CAPACITY/COMPACTION 1990

Comparison measurements at one measuring point on an oiled gravel road

----- KUAB FWD 50
——— Loadman



(Number of measurements)

Measurements performed on the oiled-gravel surface do not differ to any great extent. One difference with respect to measurements carried out on the unbound layer was that Loadman's readings were higher than those given by the falling weight deflectometer. As the number of measurements is relatively low, reliability should be improved by a further survey to investigate, among other things, the effect of ambient factors on the difference in the results.

6. DISCUSSION OF THE RESULTS

Operation: Quick and easy to use, Loadman is an efficient instrument for quality assurance purposes in site conditions. Operating costs are low compared with the other methods of measurement currently in use.

When measurements are performed with Loadman, special attention must be paid to the method of measurement and its standardization. At the moment when the measurement is made, the unit must be held in an exactly vertical position to ensure that the drop is as free as possible. Also, the drop area must be levelled (lightly with sand) to ensure that the load is evenly distributed across the entire plate.

The results seem to indicate that at least four measurements should be carried out at any one measuring point when using Loadman. The first two readings should be eliminated and the average of the two following measurements used as the final value representing the standardized result according to the curves based on the measurements.

When examining the readings obtained with Loadman in repeated measurements at one measuring point, we see that with chrushed rock aggregate with a particle size of 0 to 45 mm the results are similar for all layer thicknesses.

With chrushed rock aggregate of a particle size of 0 to 16 mm, the dispersion of the results is greater than with aggregate of a particle size of 0 to 45 mm. Also, measurements performed at one measuring point on a material with a particle size of 0 to 16 mm reveal a change in load-bearing capacity (probably due to loosening).

Another reason for the slight differences in the results measured at one measuring point with the different instruments is the separation of the fractions present in the layer to be measured.

When comparing the results of measurements obtained with the various instruments for the 20 cm thick layer, we see that the curves run more or less parallel. The only significant difference is the difference in levels, which did not seem to be affected by the variations in the thickness of the layer to be analyzed.

Measurements performed on the 30 cm thick layer show that the results obtained with the various instruments are of a similar magnitude and the difference remains much lower as compared with measurements carried out on the 20 cm thick layer.

Similarly, the results obtained with the different instruments on the 40 cm thick target layer are of the same magnitude, except for one reading given by the falling weight deflectometer which could not be explained.

With aggregate of a particle size of 0 to 16 mm, the results obtained with the falling weight deflectometer and the plate bearing instrument were very similar. Loadman's results are somewhat different, being greater at the beginning and lower towards the end of the cycle.

With respect to measurements performed on one measuring point using a plate with a diameter of 20 cm, the results vary to some extent.

The differences between Loadman and the falling weight deflectometer in measurements obtained on a bound (oiled-gravel) surface were reversed on an unbound surface, probably due to the fact that Loadman measures a thinner layer of material than the falling weight deflectometer.

For an evaluation of the usability of the unit, further studies should be carried out by using Loadman as a reference unit in normal service conditions for a longer period of time to determine its reliability, the conditions in which error occur or any other relevant variable.